(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 172 557 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
16.01.2002 Bulletin 2002/03

(51) Int Cl.7: F04B 27/10

(21) Application number: 01117137.8

(22) Date of filing: 13.07.2001

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE TR
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: 14.07.2000 JP 2000214380

(71) Applicant: Kabushiki Kaisha Toyota Jidoshokki
Kariya-shi, Aichi-ken (JP)

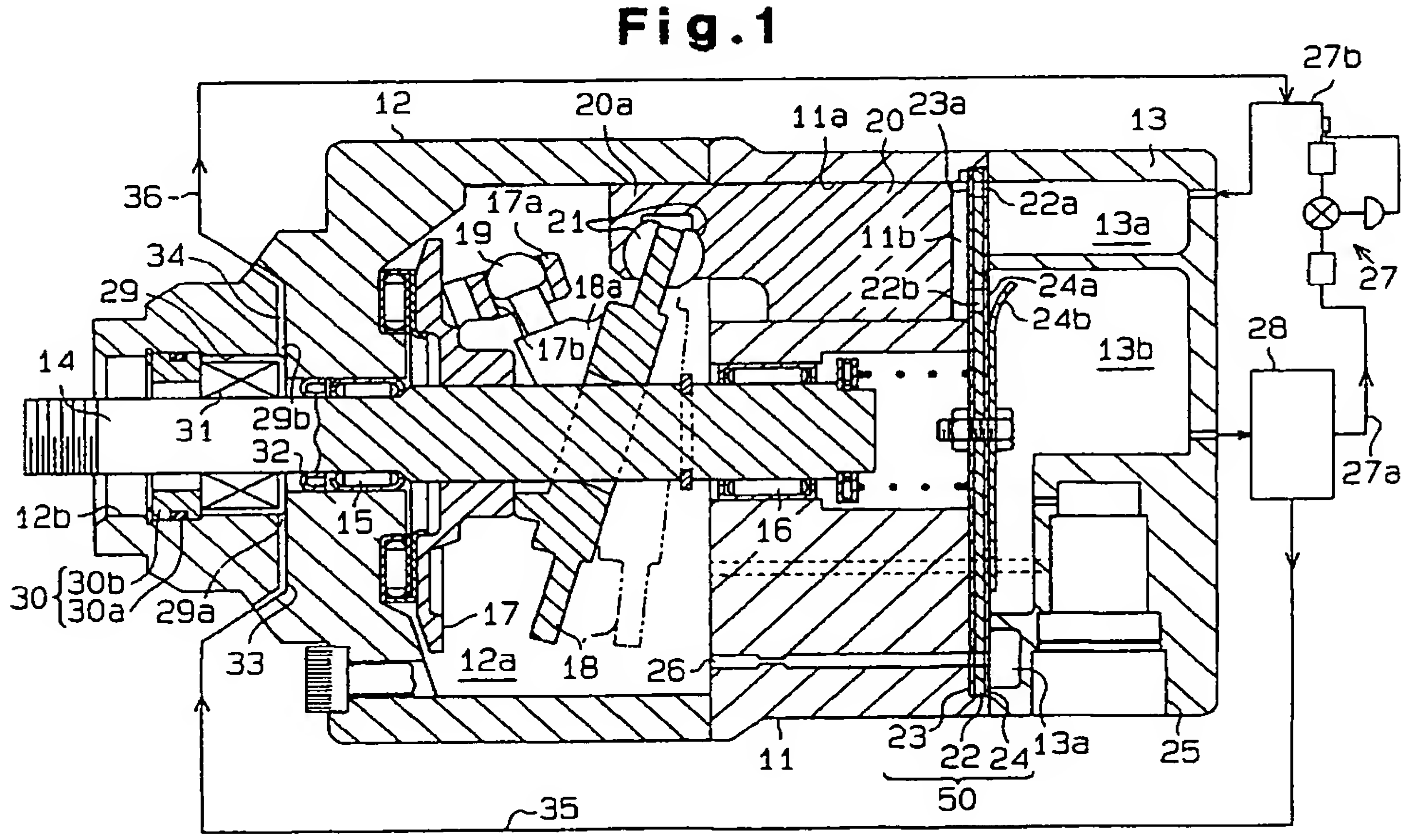
(72) Inventors:
- Yamada, Takeshi
  Kariya-shi, Aichi-ken (JP)
- Imai, Takayuki
  Kariya-shi, Aichi-ken (JP)

(74) Representative:
Leson, Thomas Johannes Alois, Dipl.-Ing.
Tiedtke-Bühling-Kinne & Partner GbR,
TBK-Patent, Bavariaring 4
80336 München (DE)

(54) **compressor**

(57) A compressor has a housing, which supports a rotary shaft (14), and a crank chamber (12a). A swash plate (18) is accommodated in the crank chamber (12a). The compressor has an oil chamber (29) located in the housing near a front end portion of the rotary shaft. The oil chamber (29) has an inlet (29a) and an outlet (29b). The outlet (29b) connects to the suction pressure zone. Either lubricant oil that is separated from refrigerant gas or refrigerant gas in the suction pressure zone flows into the oil chamber (29) from the inlet (29a) and flows out from the outlet (29b) to the suction pressure zone. A seal mechanism (30) seals the oil chamber (29). A seal (32) seals between the oil chamber (29) and the crank chamber (12a). This permits an inclination angle of the swash plate (18) to control accurately and smoothly while lubricating the seal mechanism (30) optimally.

Fig.1



EP 1 172 557 A2

Printed by Jouve, 75001 PARIS (FR)

Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to compressors provided with a seal mechanism that prevents refrigerant gas from leaking from a housing to the exterior of the housing along a rotary shaft.

[0002] Fig. 7 shows a prior art variable displacement compressor, which is described in Japanese Unexamined Patent Publication No. 11-241681. The compressor includes a housing that has a front housing member 71, a cylinder block 72, and a rear housing member 73. The front housing member 71 is securely coupled with the cylinder block 72, and the cylinder block 72 is securely coupled with the rear housing member 73. The housing rotationally supports a rotary shaft 74 through a pair of radial bearings, or a first radial bearing 75 and a second radial bearing 76. A front end of the rotary shaft 74 projects from the front housing member 71. A shaft seal 78 is fitted around the front end of the rotary shaft 74, thus preventing refrigerant gas from leaking from a crank chamber 77 to the exterior of the compressor. The refrigerant gas contains lubricant oil in the form of mist. The lubricant oil lubricates movable portions of the radial bearings 75, 76, which slide along the rotary shaft 74.

[0003] A depressurizing passage 79 is formed in the rotary shaft 74. An inlet 79a of the depressurizing passage 79 is formed in the rotary shaft 74 at a position between the first radial bearing 75 and the shaft seal 78. The inlet 79a extends in a radial direction of the rotary shaft 74 and is connected to an oil chamber 80. An outlet 79b of the depressurizing passage 79 forms an opening in a rear end of the rotary shaft 74. A fan 81 is attached to the rear end of the rotary shaft 74. The fan 81 rotates integrally with the rotary shaft 74, thus sending refrigerant gas from the depressurizing passage 79 to the exterior of the depressurizing passage 79 through the outlet 79b. The refrigerant gas then flows to the crank chamber 77 through a clearance formed by the second radial bearing 76.

[0004] The oil chamber 80 is connected to the crank chamber 77 through a clearance formed by the first radial bearing 75 and a clearance formed by a thrust bearing 82. Refrigerant gas thus flows from the crank chamber 77 to the oil chamber 80 through the clearances.

[0005] As shown in Fig. 7, the fan 81 rotates to draw some refrigerant gas from the crank chamber 77 to the depressurizing passage 79 through the clearance of the first radial bearing 75 and the clearance of the thrust bearing 82. The refrigerant gas is then discharged from the depressurizing passage 79. Afterward, some of the refrigerant gas is recirculated to the crank chamber 77 through the clearance of the second radial bearing 76. This sufficiently lubricates the first and second radial bearings 75, 76 and the shaft seal 78. However, the fan 81 complicates the configuration of the compressor.

[0006] Further, some refrigerant gas flows from the crank chamber 77 to the oil chamber 80 through a hole in which the rotary shaft 74 is received and the clearance formed by the first radial bearing 75. That is, the hole and the clearance connect the crank chamber 77 to the oil chamber 80.

[0007] The variable displacement compressor includes a drive plate 83. The drive plate 83 is inclined at an angle altered in relation to the pressure in the crank chamber 77 and the pressure in a suction chamber, or suction pressure, which both act on a piston 84. The pressure in the crank chamber 77 is thus adjusted to change the stroke of the piston 84. This varies the compressor displacement. However, if the crank chamber 77 is connected to the oil chamber 80, the compressor displacement is not varied as desired. Further, if carbon dioxide is used as refrigerant, the pressure in the compressor is greatly increased as compared to a case in which chlorofluorocarbon is used as refrigerant. This increases the load that acts on the first and second radial bearings 75, 76 and the shaft seal 78, thus requiring an increased lubrication.

[0008] Japanese Unexamined Patent Publication No. 6-66252 describes a swash plate type variable displacement compressor with double-headed pistons. The compressor includes a seal mechanism that is located near a front end of the compressor. When a front side of a double-headed piston does not compress refrigerant gas, which is referred to as "a decompressing state", lubricant oil must be supplied to the seal mechanism. Thus, in this state, refrigerant gas flows from the suction chamber to a chamber that accommodates the seal mechanism, thus lubricating the seal mechanism.

[0009] However, this structure is applicable only to swash plate type variable displacement compressors that have double-headed pistons. Thus, the structure is inapplicable to single-headed piston type variable displacement compressors.

BRIEF SUMMARY OF THE INVENTION

[0010] Accordingly, it is an objective of the present invention to provide a single-headed piston type compressor that controls inclination angle of a drive plate accurately and smoothly while lubricating a seal mechanism optimally.

[0011] To achieve the above objective, the present invention provides following a compressor. The compressor has a housing, which has a suction pressure zone, and a crank chamber. A cylinder bore is formed in the housing. A rotary shaft has a front end portion and a rear end portion. The rotary shaft is supported by the housing such that the front end portion of the rotary shaft protrudes from the housing. A piston is accommodated in the cylinder bore. A swash plate is accommodated in the crank chamber and is connected to the piston such that rotation of the rotary shaft is converted to reciprocation of the piston. An oil chamber is located in the housing near the front end portion of the rotary shaft.

The oil chamber has an inlet and an outlet. The outlet connects to the suction pressure zone. Either lubricant oil that is separated from refrigerant gas or refrigerant gas in the suction pressure zone flows into the oil chamber from the inlet and flows out from the outlet to the suction pressure zone. A seal mechanism seals the oil chamber. A seal seals between the oil chamber and the crank chamber.

[0012] Other aspects and advantages of the invention will become apparent from the following description, taken in conjunction with the accompanying drawings, illustrating by way of example the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] The invention, together with objects and advantages thereof, may best be understood by reference to the following description of the presently preferred embodiments together with the accompanying drawings in which:

Fig. 1 is a cross-sectional view showing a compressor of a first embodiment according to the present invention;

Fig. 2 is a cross-sectional view showing a compressor of a second embodiment according to the present invention;

Fig. 3 is a cross-sectional view showing a compressor of a third embodiment according to the present invention;

Fig. 4 is a cross-sectional view showing a compressor of a fourth embodiment according to the present invention;

Fig. 5 is a cross-sectional view showing a compressor of a fifth embodiment according to the present invention;

Fig. 6(a) is a cross-sectional view showing a ring seal of a sixth embodiment according to the present invention;

Fig. 6(b) is a cross-sectional view showing a ring seal of a seventh embodiment according to the present invention;

Fig. 6(c) is a cross-sectional view showing a ring seal of an eighth embodiment according to the present invention; and

Fig. 7 is a cross-sectional view showing a prior art compressor.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0014] A compressor of a first embodiment according to the present invention will now be described with reference to Fig. 1.

[0015] As shown in Fig. 1, the compressor includes a housing that has a cylinder block 11, a front housing member 12, and a rear housing member 13. The front housing member 12 and the rear housing member 13 are coupled to the cylinder block 11 through a plurality of bolts (only one is shown). The front housing member 12 and the cylinder block 11 form a crank chamber 12a. The cylinder block 11 and the front housing member 12 rotationally support a rotary shaft 14 through a first radial bearing 15 and a second radial bearing 16. More specifically, the first radial bearing 15 is received in a through hole 12b that extends through the front housing member 12, thus supporting the rotary shaft 14. The second radial bearing 16 is received in a through hole that extends through the cylinder block 11, thus supporting the rotary shaft 14. A circular lug plate 17 is secured to the rotary shaft 14 in the crank chamber 12a. A pair of support arms 17a project from an outer circumferential portion of the lug plate 17. A guide hole 17b extends through each support arm 17a.

[0016] The rotary shaft 14 supports a swash plate 18, which functions as a drive plate. The swash plate 18 inclines with respect to the rotary shaft 14 and axially slides along the rotary shaft 14. A connector 18a projects from the swash plate 18. A pair of guide pins 19 are attached to a distal end of the connector 18a.

[0017] Each guide pin 19 is fitted in the associated guide hole 17b. The lug plate 17 guides the swash plate 18 to slide along the rotary shaft 14 through the guide pins 19 fitted in the associated guide holes 17b. In other words, the swash plate 18 is allowed to incline with respect to the rotary shaft 14, axially move along the rotary shaft 14, and rotate integrally with the rotary shaft 14 by the fitting contact between the guide pins 19 and the guide holes 17b, and between the rotary shaft 14 and the swash plate 18.

[0018] A plurality of cylinder bores 11a are formed in the cylinder block 11. A single-headed piston 20 is accommodated in each cylinder bore 11a. Each piston 20 forms a compression chamber 11b in the associated cylinder bore 11a. A head 20a of each piston 20 is operationally connected to the swash plate 18 through a pair of shoes 21. When the swash plate 18 rotates in the crank chamber 12a, the rotation of the swash plate 18 is converted to reciprocation of each piston 20 through the associated shoes 21. The piston 20 thus moves in the associated cylinder bore 11a.

[0019] A suction chamber 13a and a discharge chamber 13b are formed in the rear housing member 13. A valve plate assembly 50 is located between the cylinder block 11 and the rear housing member 13. The valve plate assembly 50 includes a main plate 22, a first sub-

plate 23, and a second sub-plate 24. A plurality of suction ports 22a and a plurality of discharge ports 22b are formed in the main plate 22 at positions corresponding to the associated cylinder bores 11a. Each suction port 22a is selectively opened and closed by a corresponding suction valve 23a that is formed in the first sub-plate 23. Each discharge port 22b is selectively opened and closed by a corresponding discharge valve 24a that is formed in the second sub-plate 24. The opening size of the discharge valve 24a is restricted by a retainer 24b.

[0020] When each piston 20 moves from a bottom dead center to a top dead center, refrigerant gas flows from the compression chamber 11b, which is formed in the associated cylinder bore 11a, to the discharge chamber 13b through the associated discharge port 22b that is opened by the discharge valve 24a. In contrast, when each piston 20 moves from a top dead center to a bottom dead center, refrigerant gas flows from the suction chamber 13a to the compression chamber 11b through the associated suction port 22a that is opened by the suction valve 23a.

[0021] The stroke of each piston 20 is altered in accordance with the difference between the pressure in the crank chamber 12a and the pressure in the compression chamber 11b, or the difference between the pressure in the crank chamber 12a and the suction pressure of the compressor. In other words, the inclination angle of the swash plate 18 is altered in relation to the pressure in the crank chamber 12a. If the pressure in the crank chamber 12a increases, the inclination angle of the swash plate 18 decreases, thus reducing the compressor displacement. In contrast, if the pressure in the crank chamber 12a decreases, the inclination angle of the swash plate 18 increases, thus raising the compressor displacement.

[0022] A control valve 25 is located in the rear housing member 13. The control valve 25 adjusts the amount of the refrigerant gas that flows from the discharge chamber 13b to the crank chamber 12a. The refrigerant gas in the crank chamber 12a is supplied to the suction chamber 13a through a bleeding passage 26 that has a restrictor. The pressure in the crank chamber 12a is thus varied in relation to the amount of the refrigerant gas that flows from the crank chamber 12a to the suction chamber 13a through the bleeding passage 26, as well as the amount of the refrigerant gas that flows from the discharge chamber 13b to the crank chamber 12a, which is controlled by the control valve 25.

[0023] The suction chamber 13a is connected to the discharge chamber 13b through an external refrigerant circuit 27, which includes a first line 27a and a second line 27b. An oil separator 28 is located in the first line 27a of the external refrigerant circuit 27. The oil separator 28 incorporates a separating cylinder. Refrigerant gas is introduced to the oil separator 28 and is circulated around the separating cylinder. This causes centrifugal force that acts to separate lubricant oil from refrigerant gas. The separated lubricant oil is collected in a lower portion of the separator 28, as viewed in a state in which the compressor is installed in the vehicle.

[0024] The through hole 12b, which is formed in the front housing member 12, includes an oil chamber 29. A first seal mechanism 30 and a second seal mechanism 31 are located between the inner wall of the through hole 12b and the outer side of the rotary shaft 14. The first seal mechanism 30 and the second seal mechanism 31 serve to seal the oil chamber 29 to prevent the refrigerant gas from leaking to the outside of the housing. The first seal mechanism 30 includes a seal ring 30a that abuts against the inner wall of the through hole 12b. A support ring 30b supports the seal ring 30a. The second seal mechanism 31 contacts a facing side of the support ring 30b. The second seal mechanism 31 has a ring that rotates integrally with the rotary shaft 14.

[0025] A seal 32 is located between the second seal mechanism 31 and the first radial bearing 15. The seal 32 isolates the oil chamber 29 from the crank chamber 12a. The material of the seal 32 is, for example, rubber or fluorine contained resin. The seal 32 is a ring type that has a substantially C-shaped cross-section. The seal 32 abuts against the inner wall of the through hole 12b and the outer side of the rotary shaft 14. More specifically, the oil chamber 29 is formed by the first seal mechanism 30, the second seal mechanism 31, and the seal 32, which are located in the through hole 12b. The seal 32 axially moves along the rotary shaft 14, and the movement is restricted by a step (not shown).

[0026] The oil chamber 29 has an inlet 29a and an outlet 29b. The inlet 29a is connected to a supply passage 33. The supply passage 33 has an end that opens to the oil chamber 29. The outlet 29b is connected to a discharge passage 34. The discharge passage 34 has an end that opens to the oil chamber 29. The supply passage 33 is connected to the lower end of the oil separator 28 through a first pipe 35. The discharge passage 34 is connected to the second line 27b of the external refrigerant circuit 27 through a second pipe 36.

[0027] The operation of the compressor, which is configured as described above, will hereafter be described.

[0028] When the rotary shaft 14 is rotated, the swash plate 18 is rotated integrally with the rotary shaft 14 through the lug plate 17. The rotation of the swash plate 18 is converted to the reciprocation of each piston 20 through the associated shoes 21. Accordingly, refrigerant gas flows from the external refrigerant circuit 27 to the suction chamber 13a. The refrigerant gas is then supplied to the compression chamber 11b of each piston 20 through the associated suction port 22a. When the piston 20 is moved from the bottom dead center to the top dead center, the refrigerant gas in the compression chamber 11b is compressed to a predetermined pressure. The refrigerant gas is then discharged to the discharge chamber 13b through the associated discharge port 22b. Subsequently, the refrigerant gas is returned from the discharge chamber 13b to the external refrigerant circuit 27 through a discharge line.

[0029] A controller (not shown) controls the opening size of the control valve 25 in relation to the cooling load required for the compressor. The amount of the refrigerant gas that flows from the discharge chamber 13b to the crank chamber 12a is thus altered. If the cooling load is relatively large, the amount of the refrigerant gas that flows from the discharge chamber 13b to the crank chamber 12a is decreased. This reduces the pressure in the crank chamber 12a, thus inclining the swash plate 18 toward a maximum inclination angle. Accordingly, the stroke of each piston 20 is increased to raise the compressor displacement. In contrast, if the cooling load is relatively small, the amount of the refrigerant gas that flows from the discharge chamber 13b to the crank chamber 12a is increased. This raises the pressure in the crank chamber 12a, thus inclining the swash plate 18 toward a minimum inclination angle. Accordingly, the stroke of each piston 20 is decreased to lower the compressor displacement.

[0030] The refrigerant gas that is returned from the discharge chamber 13b to the external refrigerant circuit 27 passes through the oil separator 28. The oil separator 28 separates lubricant oil from the refrigerant gas. The refrigerant gas is then supplied to a condenser. The separated lubricant oil enters the supply passage 33 through the first pipe 35 and then flows to the oil chamber 29. The lubricant oil then enters the discharge passage 34 and flows to the second line 27b of the external refrigerant circuit 27 through the second pipe 36.

[0031] The first embodiment has the following advantages.

[0032] The seal 32 isolates the oil chamber 29 from the crank chamber 12a, thus preventing refrigerant gas from leaking from the crank chamber 12a to the oil chamber 29. Accordingly, the pressure in the crank chamber 12a is optimally adjusted to a preferred value. As a result, the inclination angle of the swash plate 18 is controlled accurately and smoothly.

[0033] The oil chamber 29 is sealed by the first seal mechanism 30, the second seal mechanism 31, and the seal 32. The oil chamber 29 is constantly supplied with lubricant oil, which is separated from refrigerant gas by the oil separator 28. Thus, lubricant oil is reliably supplied to the movable portions of the first and second seal mechanism 30, 31 and the seal 32. This structure increases lubrication of the first and second seal mechanism 30, 31 and the seal 32, thus prolonging their lives.

[0034] In the prior art, lubricant oil is supplied to the oil chamber in the form of mist, as dispersed in refrigerant gas. However, in this embodiment, the oil separator 28 separates lubricant oil from refrigerant gas. The separated lubricant oil is supplied to the oil chamber 29 in the form of liquid. This increases the amount of the lubricant oil supplied to the oil chamber 29, thus optimizing the lubrication of the first and second seal mechanisms 30, 31.

[0035] The seal 32 isolates the oil chamber 29 from the crank chamber 12a. The pressure in the oil chamber 29 remains thus lower than the pressure in the crank chamber 12a. This structure decreases the load that acts on the first and second seal mechanisms 30, 31, thus prolonging life of each seal mechanism 30, 31. Further, the refrigerant gas in the crank chamber 12a, which is relatively hot, does not enter the oil chamber 29. Thus, the temperature in the oil chamber 29 does not rise. This improves durability of each seal mechanism 30, 31.

[0036] The outlet 29b of the oil chamber 29 is located upward from the axis of the rotary shaft 14, when the compressor is installed in the vehicle. The lubricant oil that is retained in the oil chamber 29 thus constantly lubricates the rotary shaft 14. Accordingly, the first and second seal mechanisms 30, 31 are always sufficiently lubricated, and the durability of each seal mechanism 30, 31 is further improved.

[0037] If refrigerant gas leaks from the crank chamber 12a to the oil chamber 29 through the seal 32, the leaked gas is introduced to the second pipe 36 through the discharge passage 34. This structure prevents the refrigerant gas from leaking to the exterior of the compressor. In other words, as long as the inclination angle of the swash plate 18 is reliably controlled in relation to the crank pressure, the seal 32, which isolates the crank chamber 12a from the oil chamber 29, does not necessarily have to have an improved seal performance. It is thus possible to use a simply configured, inexpensive product as the seal 32.

[0038] If carbon dioxide is used as refrigerant in the compressor, pressure produced by the refrigerant in the compressor is ten or more times as high as pressure caused by chlorofluorocarbon in the compressor. Thus, in this case, the seal 32, which maintains the pressure in the oil chamber 29 at a relatively low level, is further advantageous.

[0039] The oil chamber 29 is connected to the oil separator 28 through the first pipe 35. The oil chamber 29 is also connected to the second line 27b of the external refrigerant circuit 27 through the second pipe 36. The circuit in which lubricant oil flows is thus simply configured.

[0040] Since the oil separator 28 is located in the exterior of the compressor, it is easy to replace.

[0041] Next, a second embodiment of the present invention will be described with reference to Fig. 2. Same or like reference numerals are given to parts in Fig. 2 that are the same as or line corresponding parts in Fig. 1. The description of these parts is omitted. The second embodiment is different from the first embodiment in that the oil separator 28 is located in the interior of the compressor. The oil separator 28, which is described in United States Patent No. 6,015,269 (Japanese Unexamined Patent Publication No. 10-281060), is used in this embodiment.

[0042] More specifically, as shown in Fig. 2, the oil separator 28 of the second embodiment is accommodated in the rear housing member 13. The oil separator 28 incorporates the oil separating cylinder 28a. When

refrigerant gas is circulated around the separating cylinder 28a, lubricant oil is separated from the refrigerant gas. The refrigerant gas then flows from the oil separator 28 to the discharge chamber 13b.

[0043] The oil separator 28 is connected to the inlet 29a of the oil chamber 29 through a first passage 37 and the supply passage 33. The first passage 37 extends through the rear housing member 13, the cylinder block 11, and the front housing member 12. The supply passage 33 is formed in the front housing member 12. The outlet 29b of the oil chamber 29 is connected to the suction chamber 13a through a second passage 38 and the discharge passage 34. The second passage 38 extends through the rear housing member 13, the cylinder block 11, and the front housing member 12. The discharge passage 34 is formed in the front housing member 12.

[0044] The second embodiment has the following advantage, in addition to the advantages of the first embodiment.

[0045] In the second embodiment, the oil separator 28 is accommodated in the rear housing member 13. After the oil separator 28 separates lubricant oil from refrigerant gas, the lubricant oil enters the supply passage 33 through the first passage 37, thus flowing to the oil chamber 29. The lubricant oil then enters the discharge passage 34 and is returned to the suction chamber 13a through the second passage 38. The passages 33, 34, 37, 38 are all formed in the wall of the compressor housing, which includes the front housing member 12, the cylinder block 11, and the rear housing member 13. It is thus unnecessary to locate any passages in the exterior of the compressor. Accordingly, the compressor is easy to handle.

[0046] A third embodiment of the present invention will hereafter be described with reference to Fig. 3. The second line 27b, the first pipe 35, the supply passage 33, the discharge passage 34, the second pipe 36 and suction chamber 13a form a suction pressure zone, or a low pressure zone, which is exposed to a relatively low pressure. The third embodiment is different from the first and second embodiments in that refrigerant gas is supplied from the suction pressure zone to the oil chamber 29 without separating lubricant oil from the refrigerant gas. The refrigerant gas is then returned to the suction pressure zone.

[0047] As shown in Fig. 3, an end of the first pipe 35 is connected to the second line 27b of the external refrigerant circuit 27, and the other is connected to the supply passage 33. The first pipe 35 has a branch 35a, and the branch 35a is connected to the discharge passage 34 through the second pipe 36. The third embodiment thus has the following advantage, in addition to the advantage that leakage of refrigerant gas is sufficiently suppressed.

[0048] The refrigerant gas supplied from the suction pressure zone to the oil chamber 29 contains lubricant oil in the form of mist. The lubricant oil thus optimally lubricates the first and second seal mechanisms 30, 31. Further, the oil chamber 29 is constantly supplied with relatively cool refrigerant. This suppresses heating of the first and second seal mechanisms 30, 31, thus increasing the durability of each seal mechanism 30, 31.

[0049] Next, a fourth embodiment of the present invention will be described with reference to Fig. 4. The fourth embodiment is different from the first and second embodiments in that an accumulator 39, instead of the oil separator 28, is located in the external refrigerant circuit 27.

[0050] As shown in Fig. 4, the external refrigerant circuit 27 includes the first line 27a , the second line 27b which located at the upper stream side of the accumulator 39, and a third line 27c which located at the lower stream side of the accumulator 39. The accumulator 39 is located in the external refrigerant circuit 27. The accumulator 39 prevents refrigerant liquid from entering the suction chamber 13a. That is, the accumulator 39 separates refrigerant liquid and lubricant oil from refrigerant gas. The lubricant oil is then separated from the refrigerant liquid and is accumulated in a lower portion of the accumulator 39, as viewed in a state in which the compressor is installed in the vehicle. Meanwhile, some lubricant oil remains contained in refrigerant gas and is supplied to the suction chamber 13a, together with the refrigerant gas. The lower portion of the accumulator 39 is connected to the supply passage 33 through the first pipe 35. The discharge passage 34 is connected to the third line 27c of the external refrigerant circuit 27 through the second pipe 36.

[0051] The fourth embodiment has the following advantage, in addition to the advantages of the first embodiment.

[0052] The temperature of the lubricant oil separated from the refrigerant gas by the accumulator 39 is relatively low. Since the lubricant oil is supplied to the oil chamber 29, the movable portions of the first and second seal mechanisms 30, 31, which are located in the oil chamber 29, are sufficiently cooled. This sufficiently suppresses heating of the first and second seal mechanisms 30, 31.

[0053] A fifth embodiment of the present invention will hereafter be described with reference to Fig. 5. The fifth embodiment is different from the second embodiment in that a part of the refrigerant path is formed in the rotary shaft 14.

[0054] As shown in Fig. 5, the suction chamber 13a is formed in the middle of the rear housing member 13. The discharge chamber 13b is formed around the suction chamber 13a and is located radially outward from the suction chamber 13a. An accommodating recess 40 is formed in the cylinder block 11 and receives the rear end of the rotary shaft 14. The accommodating recess 40 is connected to the suction chamber 13a through a communication hole 41 that extends through the valve plate assembly 50. A seal 42 is located between the inner wall of the accommodation recess 40 and the outer side of the rotary shaft 14.

[0055] A communication passage 43 is formed in the rotary shaft 14 and connects the accommodating recess 40 to the oil chamber 29. The communication passage 43 thus has an opening to the oil chamber 29. The opening corresponds to the inlet 29a of the oil chamber 29. A lip seal 44 , or a seal mechanism, is located between the outer side of the front end of the rotary shaft 14 and the inner wall of the front housing member 12. In the fifth embodiment, some refrigerant flows from the suction chamber 13a to the oil chamber 29 through the communication passage 43. The refrigerant then enters the discharge passage 34 and is returned to the suction chamber 13a through a passage 38 that is formed in the wall of the compressor housing. That is, refrigerant circulates only in the compressor, and it is unnecessary to install a refrigerant passage in the exterior of the compressor.

[0056] It should be apparent to those skilled in the art that the present invention may be embodied in many other specific forms without departing from the spirit or scope of the invention. Particularly, it should be understood that the invention may be embodied in the following forms.

[0057] The seal 32 does not necessarily have to be a ring type that has a C-shaped cross-sectional shape. For example, in a sixth embodiment shown in Fig. 6(a), the seal 32 is a ring type that has an L-shaped cross section. The seal 32 of this embodiment is formed of polytetrafluoroethylene (PTFE). Further, in a seventh embodiment shown in Fig. 6(b), the seal 32 is an oil seal type. Alternatively, in an eighth embodiment shown in Fig. 6(c), the seal 32 is a ring type that has a square-shaped cross section. Likewise, the seal 42, which is shown in Fig. 5, may be a ring type that has a C-shaped or square-shaped cross section. Alternatively, the seal 42 may be an oil seal type.

[0058] Further, a lip seal may be used in embodiments other than the fifth embodiment, which is shown in Fig. 5.

[0059] In the first, third, and fourth embodiments, the second pipe 36 may be replaced by the passage 38, which is formed in the wall of the compressor housing. In this case, refrigerant or lubricant oil is returned to the suction chamber 13a through the passage 38. Alternatively, the second pipe 36 may be connected directly to the suction chamber 13a, instead of being connected to the suction chamber 13a through the second line 27b of the external refrigerant circuit 27.

[0060] In the illustrated embodiments, the outlet 29b of the oil chamber 29 is located in an upper section of the oil chamber 29, as viewed in a state in which the compressor is installed in the vehicle. However, the outlet 29b may be located in a lower section of the oil chamber 29.

[0061] The seal 32 may be located between the radial bearing 15 and the crank chamber 12a. In this case, the radial bearing 15 is located in the oil chamber 29 and is sufficiently lubricated.

[0062] The present invention may be applied to a fixed displacement type compressor.

[0063] The present invention may be applied to a wobble plate type compressor. In this compressor, a wobble plate, or a drive plate, is supported by a rotary shaft and rotates relative to the rotary shaft.

[0064] Therefore, the present examples and embodiments are to be considered as illustrative and not restrictive and the invention is not to be limited to the details given herein, but may be modified within the scope and equivalence of the appended claims.

A compressor has a housing, which supports a rotary shaft (14), and a crank chamber (12a). A swash plate (18) is accommodated in the crank chamber (12a). The compressor has an oil chamber (29) located in the housing near a front end portion of the rotary shaft. The oil chamber (29) has an inlet (29a) and an outlet (29b). The outlet (29b) connects to the suction pressure zone. Either lubricant oil that is separated from refrigerant gas or refrigerant gas in the suction pressure zone flows into the oil chamber (29) from the inlet (29a) and flows out from the outlet (29b) to the suction pressure zone. A seal mechanism (30) seals the oil chamber (29). A seal (32) seals between the oil chamber (29) and the crank chamber (12a). This permits an inclination angle of the swash plate (18) to control accurately and smoothly while lubricating the seal mechanism (30) optimally.

Claims

1. A compressor comprising:

   a housing, which has a suction pressure zone, and a crank chamber (12a);
   a cylinder bore (11a) formed in the housing;
   a rotary shaft (14), which has a front end portion and a rear end portion, wherein the rotary shaft (14) is supported by the housing such that the front end portion of the rotary shaft (14) protrudes from the housing;
   a piston (20) accommodated in the cylinder bore (11a);
   a swash plate (18), which is accommodated in the crank chamber (12a) and is connected to the piston (20) such that rotation of the rotary shaft (14) is converted to reciprocation of the piston (20), the compressor **being**

   characterized by:

   an oil chamber (29) located in the housing near the front end portion of the rotary shaft (14), wherein the oil chamber (29) has an inlet (29a) and an outlet (29b), wherein the outlet (29b) connects to the suction pressure zone, wherein either lubricant oil that is separated from refrigerant gas or refrigerant gas in the suction pressure zone flows into the oil chamber (29) from

the inlet (29a) and flows out from the outlet (29b) to the suction pressure zone;
a seal mechanism (30, 31, 44) for sealing the oil chamber (29); and
a seal (32) for sealing between the oil chamber (29) and the crank chamber (12a).

2. The compressor according to claim 1, **characterized in that** the seal mechanism (30, 31, 44) is located in the vicinity of the front end portion of the rotary shaft (14), wherein the seal (32) is located between the seal mechanism (30, 31, 44) and the crank chamber (12a).

3. The compressor according to claims 1 or 2, **characterized in that** the inclination of the swash plate (18) is changed in accordance with the pressure of the crank chamber (12a), and a stroke of the piston (20) is changed.

4. The compressor according to any one of claims 1 to 3, **characterized in that** a pipe (36, 38) connects the outlet (29b) of the oil chamber (29) to the suction pressure zone.

5. The compressor according to any one of claims 1 to 4 further being **characterized by** connected to an external refrigerant circuit (27), wherein the compressor has an oil separator (28, 39), which separates lubricant oil from the refrigerant gas, wherein the oil separator (28, 39) is connected to the external refrigerant circuit (27).

6. The compressor according to claim 5, **characterized in that** the oil separator is an accumulator (39), which separates refrigerant liquid and refrigerant gas.

7. The compressor according to any one of claims 1 to 4, **characterized in that** an separator (28) is accommodated in the compressor, wherein the lubricant oil separated by the oil separator (28) is introduced to the oil chamber (29) through the inlet (29a) of the oil chamber (29).

8. The compressor according to any one of claims 1 to 7, **characterized in that** the outlet (29b) of the oil chamber (29) is located above the axis of the rotary shaft (14).

9. The compressor according to any one of claims 1 to 8, **characterized in that** the seal (32) is located in the periphery of the rotary shaft (14), wherein the seal (32) has a C-shaped cross section.

10. The compressor according to any one of claims 1 to 8, **characterized in that** the seal (32) has an L-shaped cross section.

11. The compressor according to any one of claims 1 to 8, **characterized in that** the seal (32) has a square-shaped cross section.

Fig.1

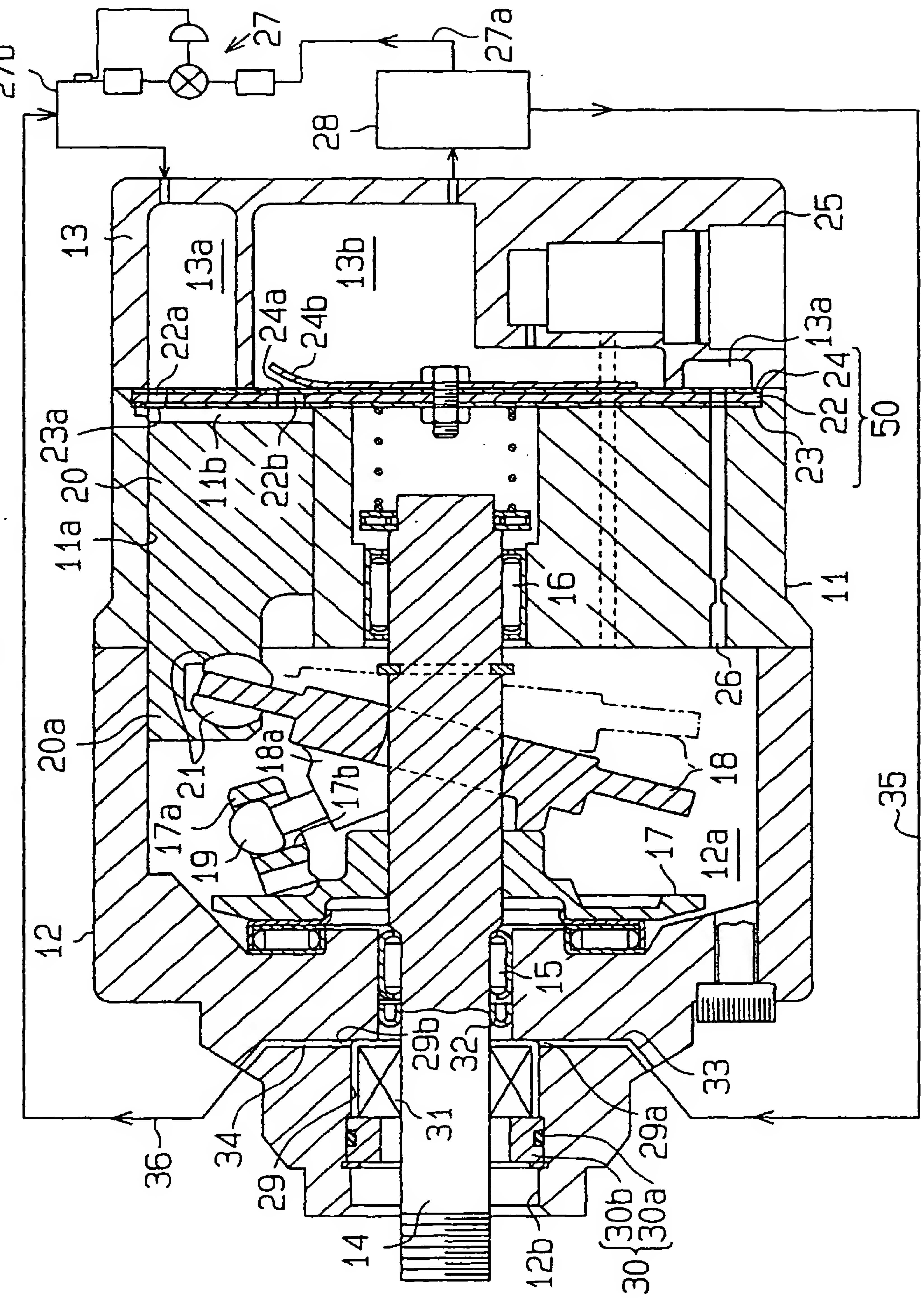

27b
27
27a
28
13
13a
13b
25
22a
24a
24b
13a
24
22
23
50
23a
20
11b
22b
11a
16
11
26
20a
21
18a
17a
17b
18
19
17
12a
35
12
15
29b
32
33
36
34
31
29a
29
30b
30a
30
14
12b

Fig.2

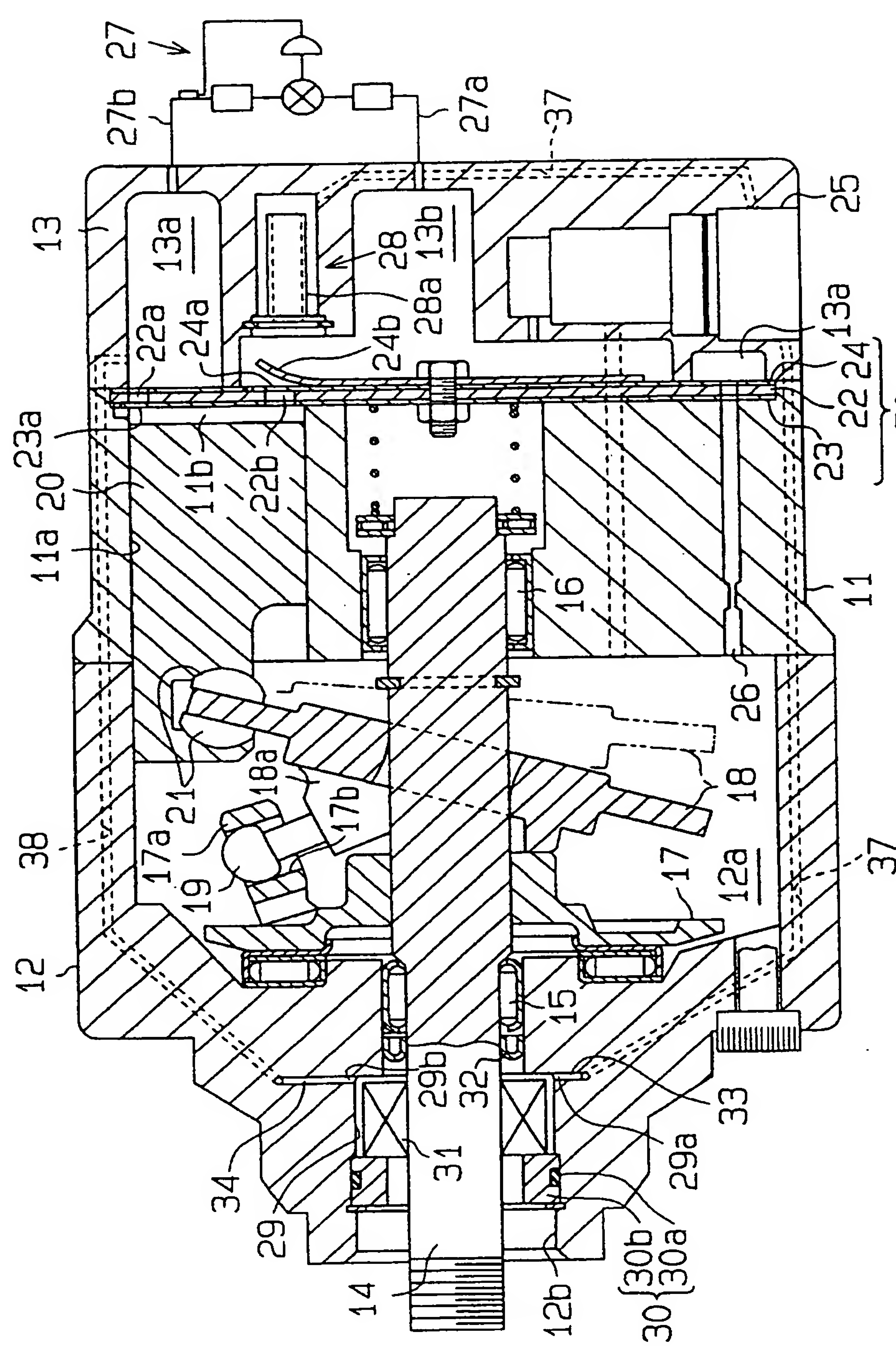

27
27b
27a
37
13
13a
28
13b
28a
25
22a
24a
24b
13a
24
22
50
23a
20
11b
22b
23
11a
16
11
26
38
21
18a
17a
17b
18
19
17
12a
37
12
15
29b
32
33
34
31
29a
29
30b
30a
14
12b
30

Fig.3

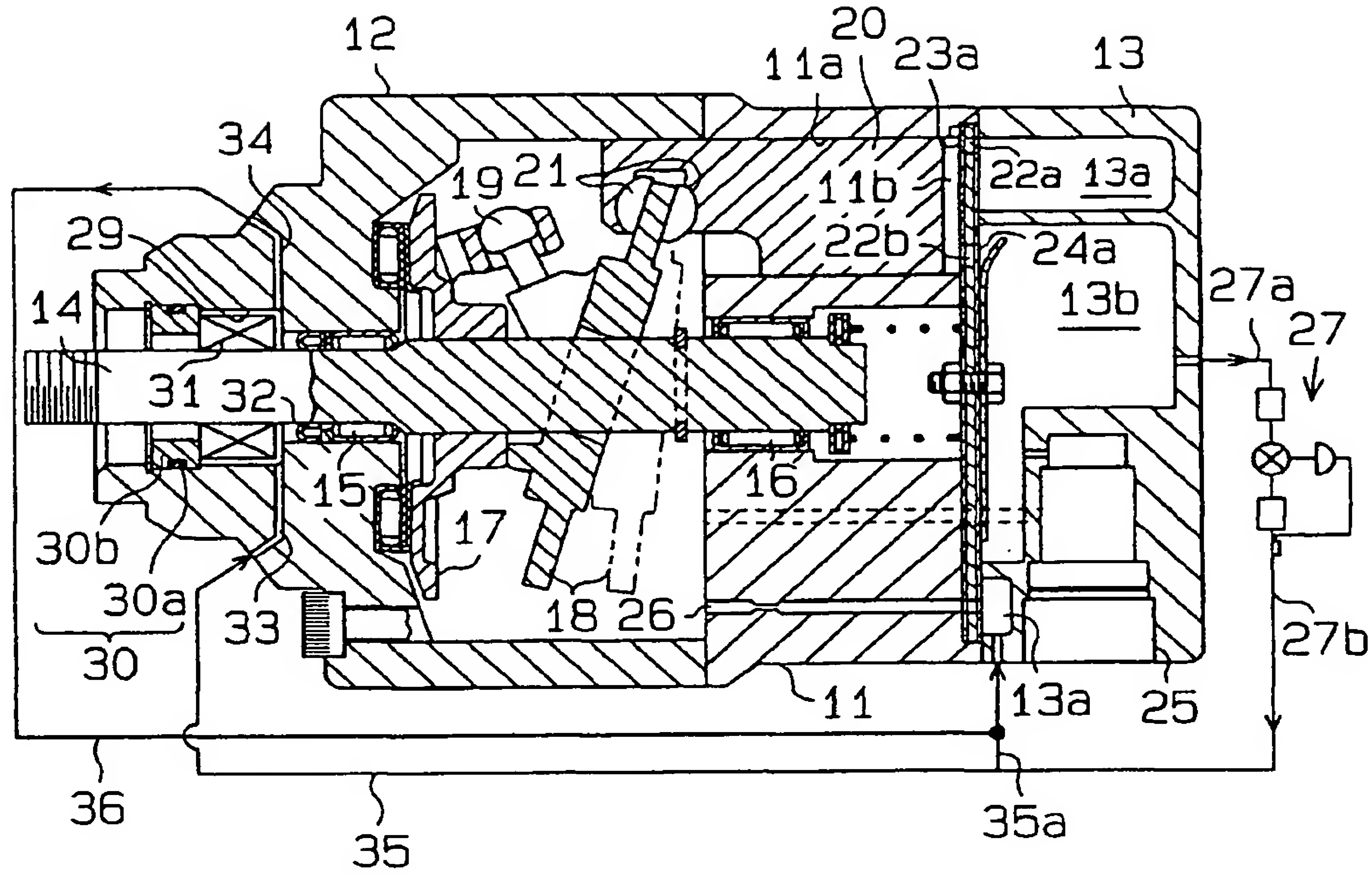
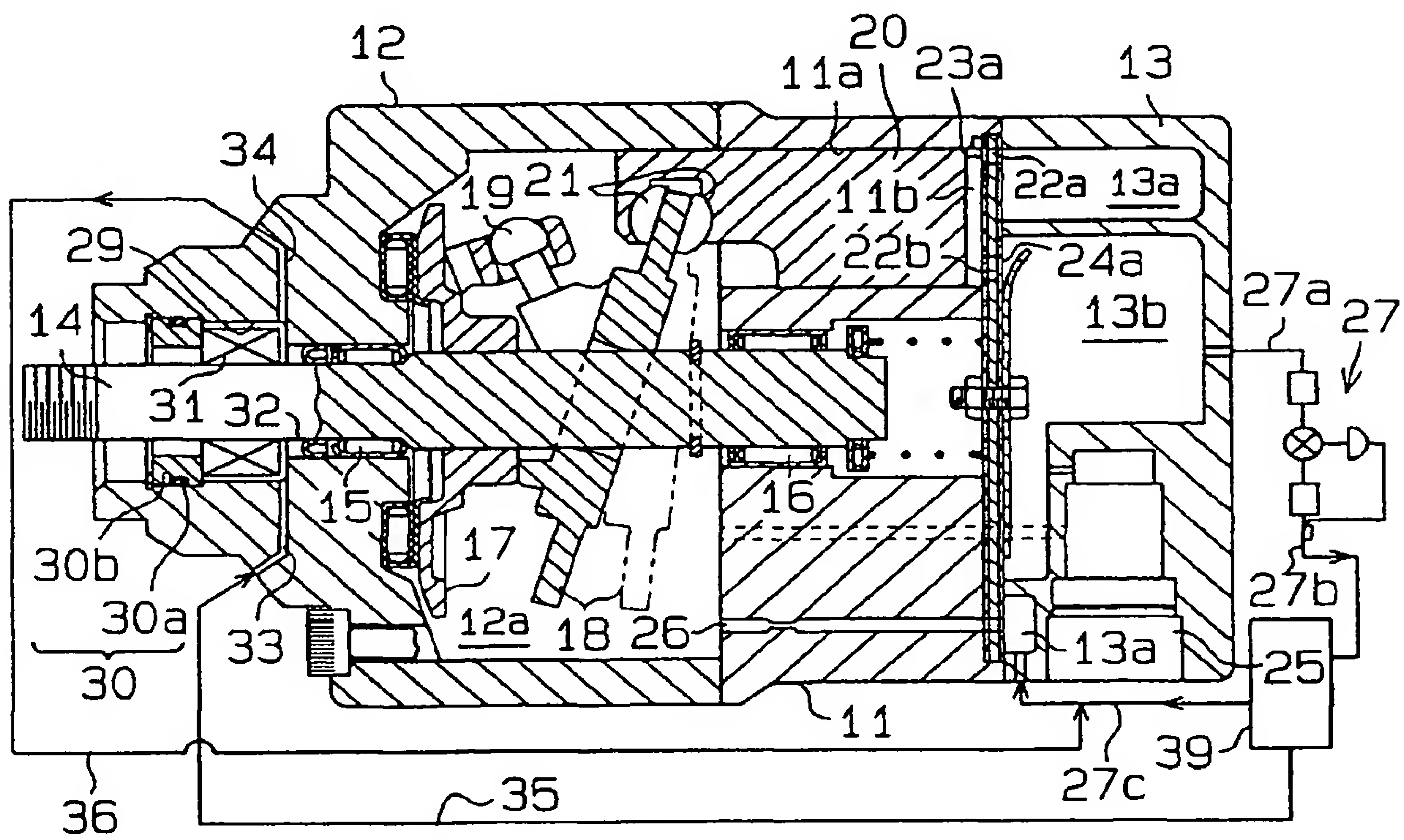

12
20
11a
23a
13
34
19
21
11b
22a
13a
29
22b
24a
27a
14
13b
27
31
32
15
16
17
30b
30a
18
26
33
27b
30
11
13a
25
36
35
35a

Fig.4


12
20
11a
23a
13
34
19
21
11b
22a
13a
29
22b
24a
27a
27
14
13b
31
32
15
16
30b
17
27b
30a
12a
18
26
13a
25
33
30
11
39
27c
36
35

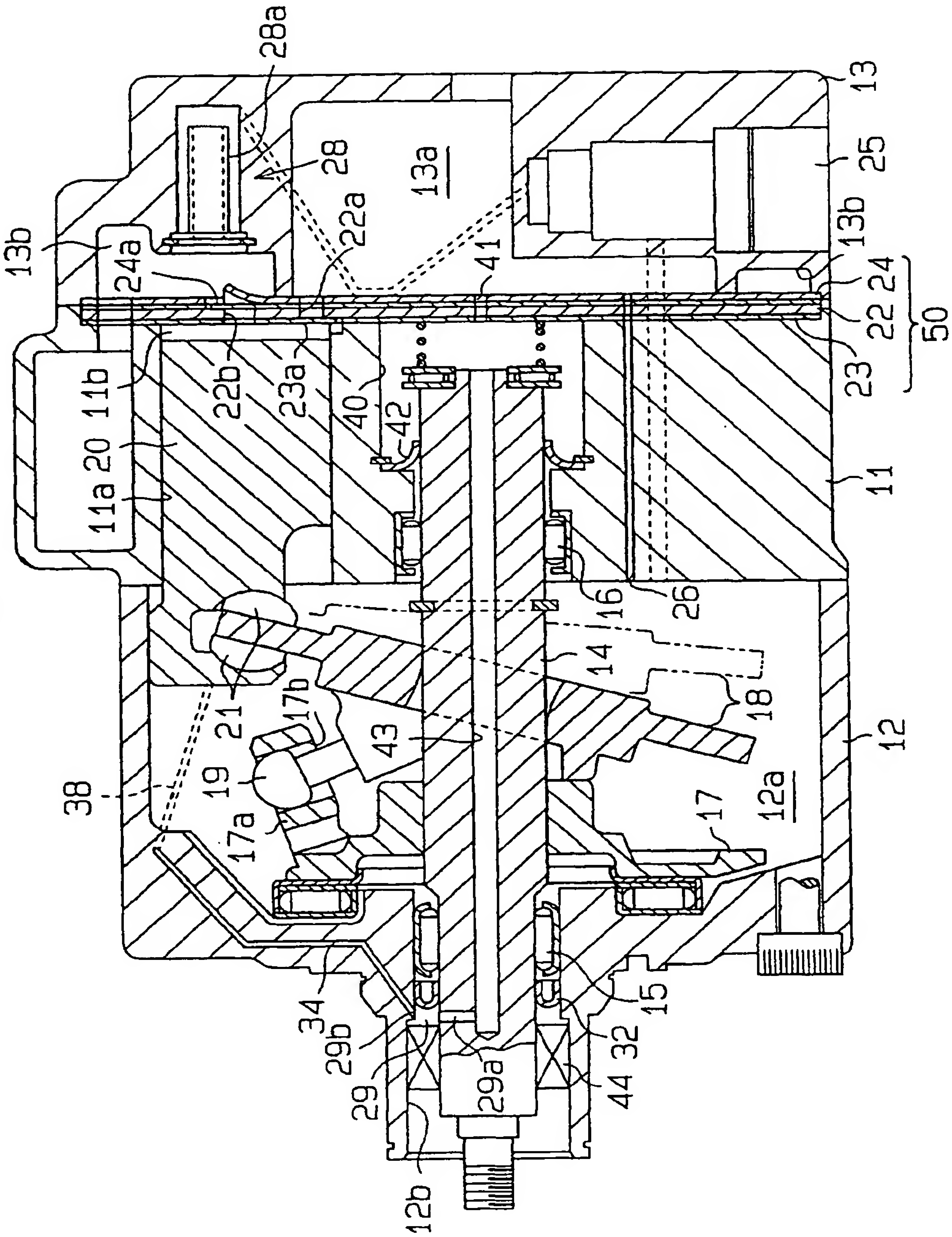

28a
13
28
13a
25
13b
22a
24a
41
24
22
50
23
11b
22b
23a
40
42
11a 20
11
16
26
14
21
17b
18
43
19
38
17
12a
12
17a
34
15
29b
32
29
29a
44
12b

Fig.5

Fig.6(a)

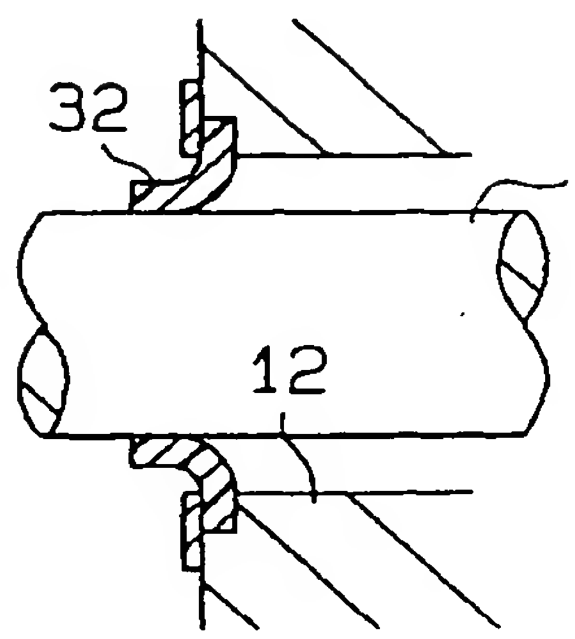


Fig.6(b)

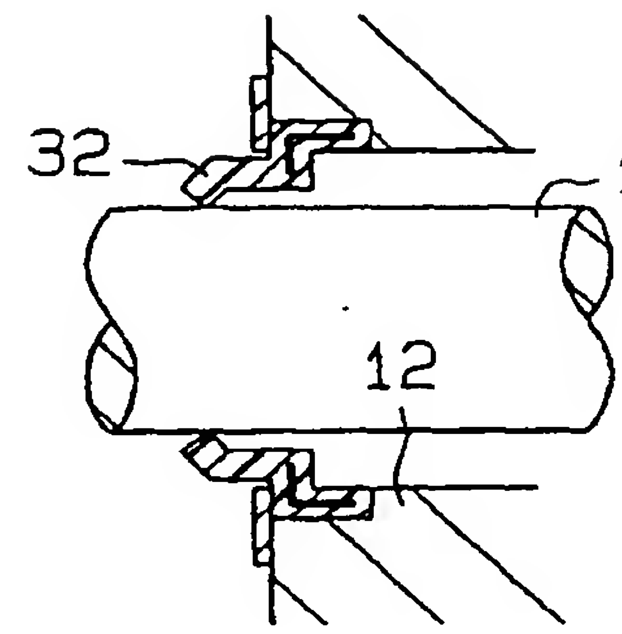


Fig.6(c)

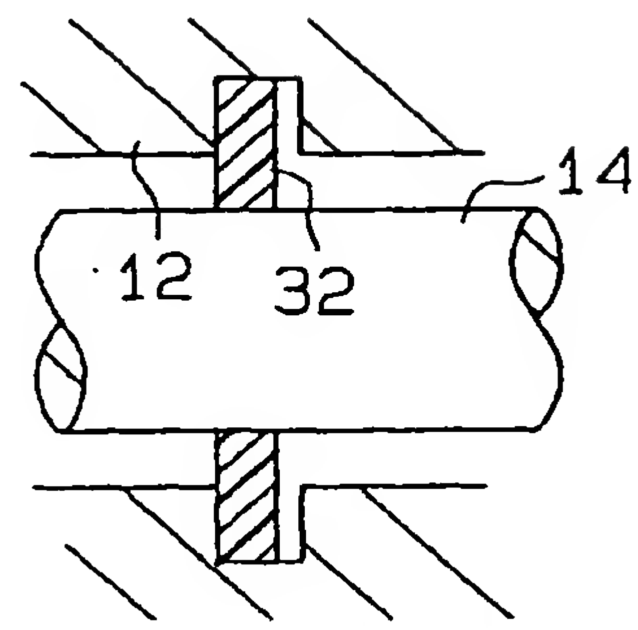


Fig.7